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(54) **Fluid actuated friction damper.**

(57) The fluid actuated friction damper comprises a cylinder (10) and an expandable piston assembly (12) made up of a postion having two spaced apart parallel end walls (24) which form an annular chamber (28), and two spaced apart side walls which project toward one another and terminate in two spaced apart parallel edges (34,36). These edges define a curved opening for the chamber which fronts upon the inside of the cylinder. A curved friction member (18,20) is located between these edges in this opening, and is pressed against the inside of the cylinder (10) by an underlying flexible actuator ring.(22) This ring has a width greater than the spacing between the side wall edges (34,36) and is located inside of the side walls so that the ring simultaneously self-seals against the side walls and bulges outwardly through the opening, thereby pressing the friction member (18,20) against the inside of the cylinder when the chamber is pressurized. The friction member (18,20) is contained in a fixed position with respect to the piston (16) between the side wall edges, the inside of the cylinder and the flexible actuator ring.(22) The frictional damping force obtained is controllable in relation to the direction of movement of the piston assembly within the cylinder, either by control of the fluid pressure applied to the chamber or by control of the surface area of the actuator ring exposed to a single fluid pressure, using fluid pressures less than 35 psi.

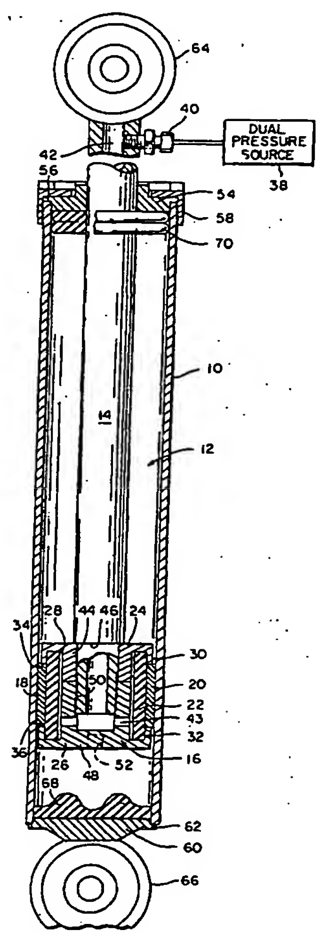

FIG. 1

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The damper comprises a cylinder and an expandable piston assembly made up of a piston having two spaced apart parallel end walls which form an annular chamber, and two spaced apart side walls which project toward one another and terminate in two spaced apart parallel edges. These edges define a curved opening for the chamber which fronts upon the inside of the cylinder. A curved friction member is located between these edges in this opening, and is pressed against the inside of the cylinder by an underlying flexible actuator ring. This ring has a width greater than the spacing between the side wall edges and is located inside of the side walls so that the ring simultaneously self-seals against the side walls and bulges outwardly through the opening, thereby pressing the friction member against the inside of the cylinder when the chamber is pressurized. The friction member is contained in a fixed position with respect to the piston between the side wall edges, the inside of the cylinder and the flexible actuator ring. The frictional damping force obtained is controllable in relation to the direction of movement of the piston assembly within the cylinder, either by control of the fluid pressure applied to the chamber or by control of the surface area of the actuator ring exposed to a single fluid pressure, using fluid pressures less than 35 psi.

Background of the Invention

This invention relates to friction dampers and, more particularly, to friction dampers in which the frictional damping force obtained is controllable.

Most friction dampers of this type provide control of the frictional damping force obtained by selective adjustment of the normal force applied to one or more friction members which rub against one of two or more relatively movable members. This adjustment typically is accomplished by selective wedging of the friction members against one of the movable members by a jack screw, spring or shim which, once set, applies a constant normal force to the friction members.

In many applications, however, it is desirable to vary the frictional damping force obtained in relation to a desired environmental parameter. Some automotive suspensions, for example, vary the frictional damping force obtained in relation to the load applied to a strut or to the pressure inside of a gas spring. Certain aircraft landing gear also do so, but in relation to the velocity of movement of an oleo strut. Some of these devices use fluid pressure to actuate the friction members.

The fluid pressure actuated friction dampers most commonly used in such devices include inflatable bladders or folded membranes to control the normal force applied to the friction member or members, and hence the frictional damping force obtained. These tend to be unsatisfactory. The bladder or membrane must be folded back upon itself and therefore requires complex sealing and positioning devices to maintain it in the proper alignment with the friction members.

As the friction members wear away, moreover, this alignment tends to degrade as the bladder or membrane bulges more and more to take up the attendant slack. In extreme cases, the folds can become so misaligned that the fluid seal may be lost. Further, as the fluid pressure increases, so do the chances of a seal failure. This is especially true in those devices which are used with gas springs, since they typically must operate at pressures of 100-125 pounds per square inch (psi).

Summary of the Invention

According to one aspect of the invention, there is provided a friction damper, comprising a cylinder and an expandable piston assembly movable in and out of the cylinder. The piston assembly includes a shaft, a hollow piston supported by the shaft, a curved friction member carried by the piston, and fluid actuator means acting between the piston and the friction member for pressing the friction member against the inside of the cylinder in response to a fluid pressure inside of the piston. The piston includes two spaced apart parallel end walls forming a chamber facing the inside of the cylinder, and two spaced apart side walls respectively projecting from the end walls toward one another, and terminating in two spaced apart parallel edges, the edges defining a curved opening for the chamber fronting upon the inside of the cylinder. The fluid actuator means includes a flexible actuator ring having a width greater than the spacing between the edges, the actuator ring being located inside of the side walls such that the actuator ring simultaneously self-seals against the side walls and bulges outwardly through the opening, thereby pressing the friction member against the inside of the cylinder, when the chamber is pressurized. The friction member has an outline registering with the opening, and is contained in a fixed position with respect to the piston between the edges, the inside of the cylinder, and the actuator ring.

This invention attempts to provide a fluid actuated friction damper in which the fluid actuator need not be a bladder or folded membrane, and thus is of simple, low cost design and construction, and hence eliminates or minimizes the risk of a fluid seal failure.

This invention also attempts to provide a fluid actuated friction damper in which the fluid actuator is self-sealing in response to application of fluid pressure, without any supplemental sealing or positioning means.

This invention further attempts to provide a fluid actuated friction damper in which the fluid actuator and one or more friction members are carried and positioned by a simple housing or piston construction.

This invention attempts to provide a fluid actuated friction damper in which the fluid actuator is responsive to fluid pressures less than those commonly used in gas springs.

This invention attempts to provide a fluid actuated friction damper in which the frictional damping force obtained is controllable in relation to extension and contraction of the friction damper under rebound conditions or jounce conditions, or both.

This invention attempts to provide a fluid actuated friction damper in which the frictional damping force obtained is controllable either by controlling the fluid pressure applied to, or the area of, a fluid actuator in relation to extension and contraction of the friction damper under rebound conditions, or jounce conditions, or both.

Finally, this invention attempts to provide a fluid actuated friction damper in which the different pressures that occur at opposite ends of a closed-ended cylinder, or adjacent one face of a piston, while the piston moves in and out of the cylinder, are used as basis to sense the direction of movement of the piston for controlling the frictional damping force obtained.

These desires are accomplished in accordance with the principles of this invention by providing a friction damper comprising a cylinder and an expandable piston assembly which is movable in and out of the cylinder. The piston assembly includes a shaft having one end projecting out of one end of the cylinder, a hollow piston supported by the other end of the shaft, a curved friction member carried by the piston, and fluid actuator means acting between the piston and the friction member for pressing the friction member against the inside of the cylinder in response to fluid pressure inside the piston. This fluid pressure preferably, is, but need not be, applied through a bore formed in the shaft.

The piston includes two spaced apart parallel end walls which form a chamber facing the inside of the cylinder, and two spaced apart side walls which respectively project from the end walls toward one another and terminate in two spaced apart parallel edges. These edges define a curved opening for the chamber which fronts upon the inside of the cylinder. The friction member has an outline which registers with this opening, and is located in this opening between the side wall edges.

The fluid actuator means includes a flexible actuator ring which has a width greater than the spacing between the side wall edges, and is located inside of the side walls so that it simultaneously self-seals against the side walls and bulges outwardly through the chamber opening, thereby pressing the friction member against the inside of the cylinder, when the chamber is pressurized. The friction member is contained in a fixed position with respect to the piston between the side wall edges, the inside of the cylinder and this ring. One, two, three, four or more curved friction members may be used.

According to further principles of this invention, the fluid actuator means are further operative to control the frictional damping force applied to the inside of the cylinder by the friction member in relation to the direction of movement of the piston inside of the cylinder. While preferably the frictional damping force obtained is greater during extension of the piston, or under rebound conditions, than the frictional damping force obtained during contraction of the piston, or under jounce conditions, the opposite frictional damping force differential may be obtained.

According to a first presently preferred embodiment of the present invention, such control is accomplished by applying two fluid pressures to the chamber, and hence to the inside of the actuator ring, in alternate sequence. In those applications in which the frictional damping force obtained under rebound conditions should be greater than that obtained under jounce conditions, the fluid pressures thus applied are correspondingly differentiated.

According to a second presently preferred embodiment of this invention, such control is accomplished by isolating the inside surface area of the actuator ring into two sections, and exposing only one or both sections to a single fluid pressure in alternate sequence. Under conditions where a lower frictional damping force is required (e.g., under jounce conditions) only one section is exposed to the fluid pressure. Under other conditions in which a higher frictional damping force is required (e.g., under rebound conditions), however, both sections are exposed to the fluid pressure simultaneously.

According to further principles of this invention, the cylinder is closed at each end so that the piston divides it into two pressure chambers, the volumes of which vary as the piston moves in and out of the cylinder under jounce and rebound conditions. By connecting these chambers, fluid will flow between them in opposite directions during such movement of the piston. This fluid flow re-

valve 124 is open. When closed, valve 124 presses an O-ring 133 against section 48' and blocks passage 132 so no pressure fluid can escape from chamber 28'. An O-ring 135 provides a seal about the stem portion of valve 124 downstream of passage 132.

During extension of assembly 12' under rebound conditions, the resultant drop in pressure downstream of diaphragm 122 (or below it as illustrated) causes diaphragm 122 to be displaced to the position depicted in broken lines. Valve 124 then opens orifice 128 to admit fluid pressure to chamber 28'. As will now be appreciated, this causes friction members 18' and 20' to be pressed against the inside of cylinder 10'.

During contraction of assembly 12' under jounce conditions, however, diaphragm 122 remains in the position depicted in solid lines, and spring 126 pulls valve 126 against and thus closes orifice 128. Since fluid pressure now is exhausted from chamber 28' via passage 132 and is not rereplaced by fresh pressure fluid, there is insufficient fluid pressure inside of chamber 28' to deform actuator ring 22' under these conditions. Consequently, friction members 18' and 20' are inactive, unlike the Fig. 1 actuator a bearing 136 composed of a suitable low friction material is carried by section 48' guides movement of assembly 12' within cylinder 10.

While three presently preferred embodiments of this invention have been illustrated and described herein, variations will become apparent to one of ordinary skill in the art. For example, the fluid pressure adjacent piston 16' could be transmitted to and sensed at a location outside of cylinder 10', rather than at diaphragm 122, so long as fluid pressure in chamber 28' is controlled in the manner described. Accordingly, the invention is not to be limited to the specific embodiment illustrated and described herein, and the true scope and spirit of the invention are to be determined by reference to the appended claims.

Claims

1. A friction damper, comprising:

   a cylinder and an expandable piston assembly movable in and out of said cylinder;

   said piston assembly including a shaft, a hollow piston supported by said shaft, a curved friction member carried by said piston, and fluid actuator means acting between said piston and said friction member for pressing said friction member against the inside of said cylinder in response to a fluid pressure inside of said piston;

   said piston including two spaced apart parallel end walls forming a chamber facing the inside of said cylinder, and two spaced apart side walls respectively projecting from said end walls toward one another, and terminating in two spaced apart parallel edges, said edges defining a curved opening for said chamber fronting upon the inside of said cylinder;

   said fluid actuator means including a flexible actuator ring having a width greater than the spacing between said edges, said actuator ring being located inside of said side walls such that said actuator ring simultaneously self-seals against said side walls and bulges outwardly through said opening, thereby pressing said friction member against the inside of said cylinder, when said chamber is pressurized;

   said friction member having an outline registering with said opening, and being contained in a fixed position with respect to said piston between said edges, the inside of said cylinder, and said actuator ring.

2. The damper of claim 1, wherein said fluid actuator means are further operative to control the fluid pressure within said chamber in relation to the direction of movement of said piston assembly with respect to said cylinder.

3. The damper of claim 2, wherein said fluid actuator means include a source of two different fluid pressures, and means for pressuring said chamber (1) with one of said fluid pressures during movement of said assembly in one direction and (2) with the other of said fluid pressures during movement of said assembly in the opposite direction.

4. The damper of claim 2, wherein said friction member is made up of two independently movable sections and said chamber is divided into two separately pressurizable spaces, and wherein said fluid actuator means include means for pressurizing (1) only one of said spaces with a single fluid pressure during movement of said assembly in one direction and (2) both of said spaces is simultaneously with said single fluid pressure during movement of said assembly in the opposite direction.

5. A friction damper, comprising:

   two telescopically movable load bearing

members and frictional damping means supported by one of said load bearing members for applying a frictional damping force to the other of said load bearing members;

said damping means including a housing, a curved friction member carried by said housing, and fluid actuator means acting between said housing and said friction member for pressing said friction member against said other load bearing member in response to a fluid pressure inside of said housing;

said housing including two spaced apart end walls forming a chamber facing said other load bearing member, and two spaced apart side walls respectively projecting from said end walls toward one another, and terminating in two spaced apart parallel edges, said edges defining a curved opening for said chamber fronting upon said other load bearing member;

said fluid actuator means including a flexible actuator ring having a width greater than the spacing between said edges, said actuator ring being located inside of said side walls such that said actuator ring simultaneously self-seals against said side walls and bulges outwardly through said opening, thereby pressing said friction member against said other load bearing member when said chamber is pressurized;

said friction member having an outline registering with said opening, and being contained in a fixed position with respect to said one load bearing member between said edges, said other load bearing member, and said actuator ring;

6. The damper of claim 5, wherein said fluid actuator means include pressure fluid sensor means for causing said chamber to be pressurized solely during movement of said load bearing members in a predetermined direction of movement in response to a change in fluid pressure adjacent said housing.

7. The damper of claim 6, wherein said other load bearing member is a closed-ended cylinder, and said sensor means include a displaceable diaphragm exposed to fluid pressure within one end of said cylinder such that said diaphragm moves to a predetermined position only when said one load bearing member and said cylinder move in a predetermined direction with respect to one another, and a valve actuated by displacement of said diaphragm for admitting fluid pressure into said chamber only when said diaphragm assumes said predetermined position.

FIG. 1

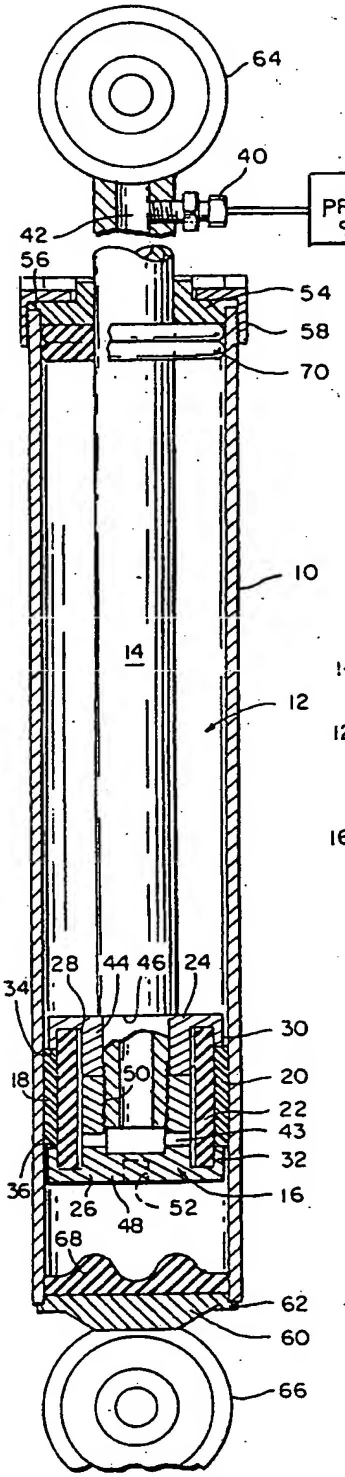


FIG. 2

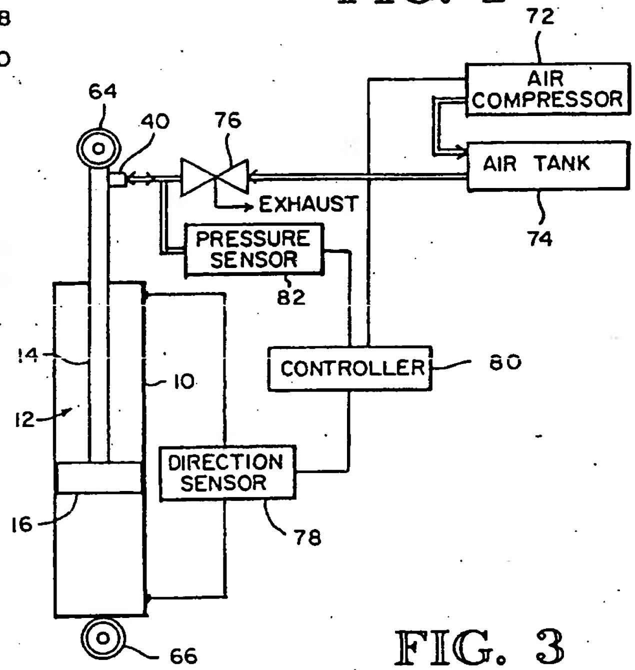


FIG. 3

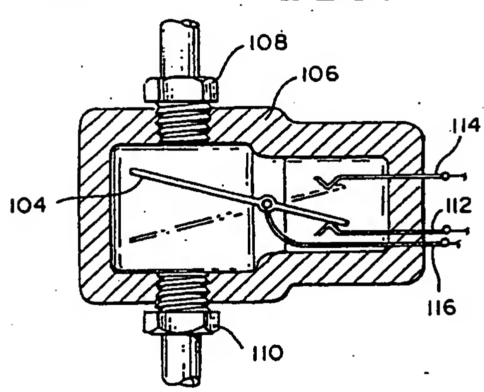


FIG. 4

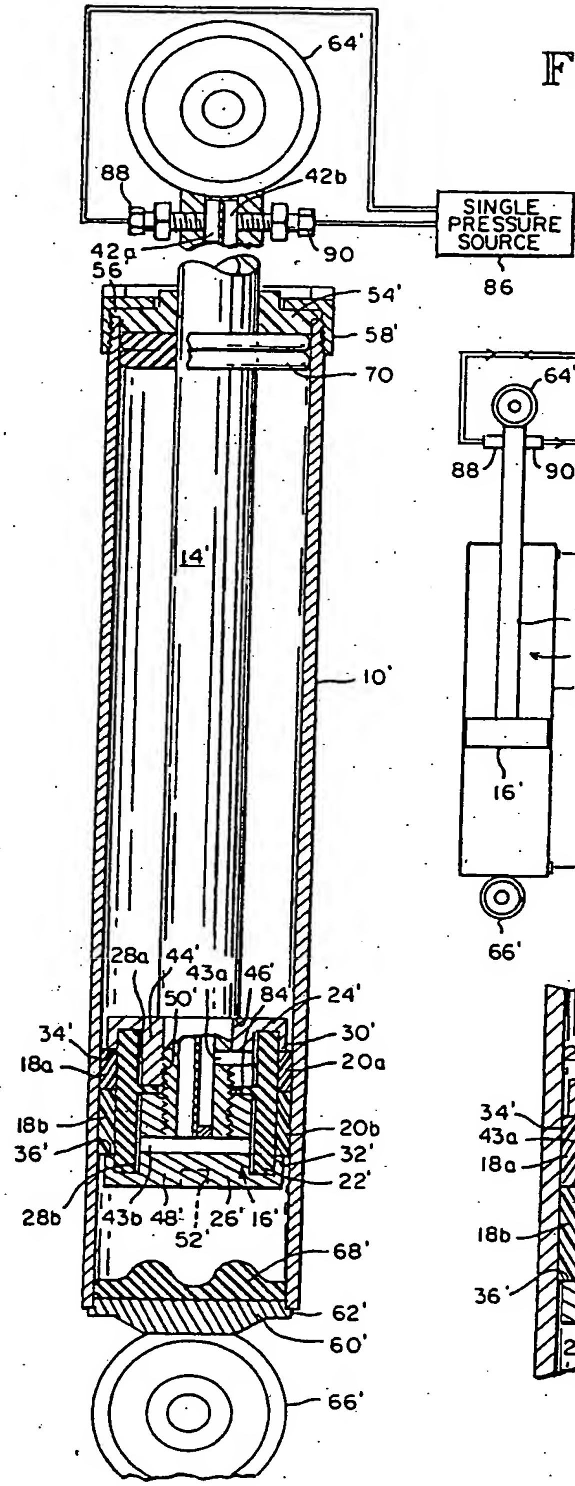


FIG. 5

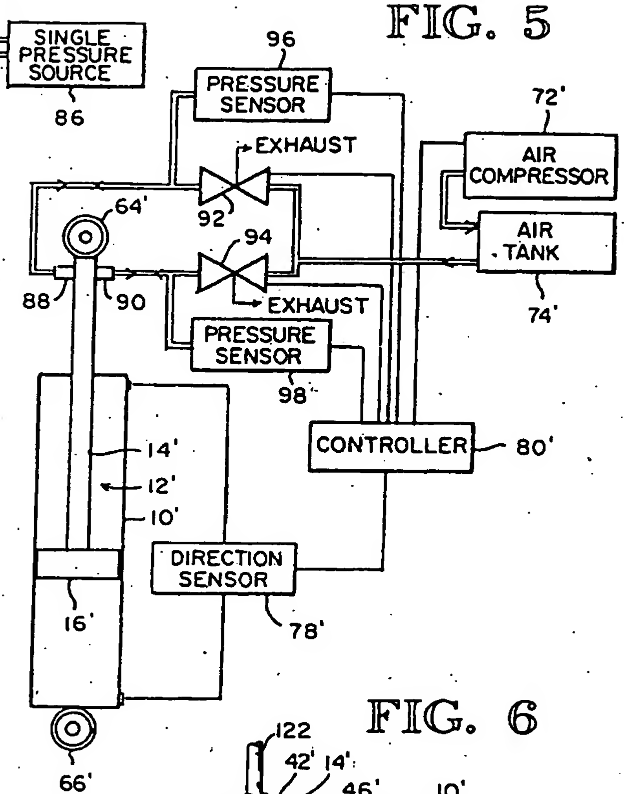


FIG. 6

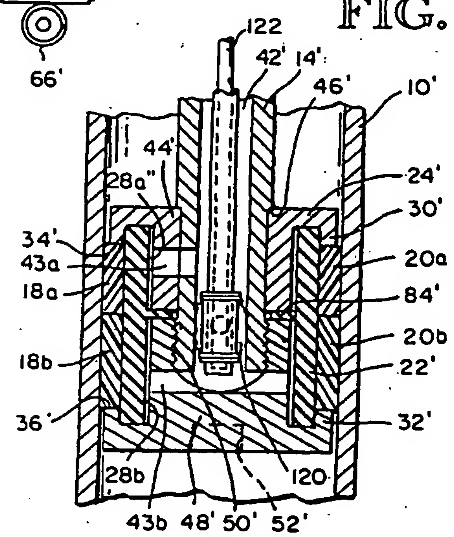
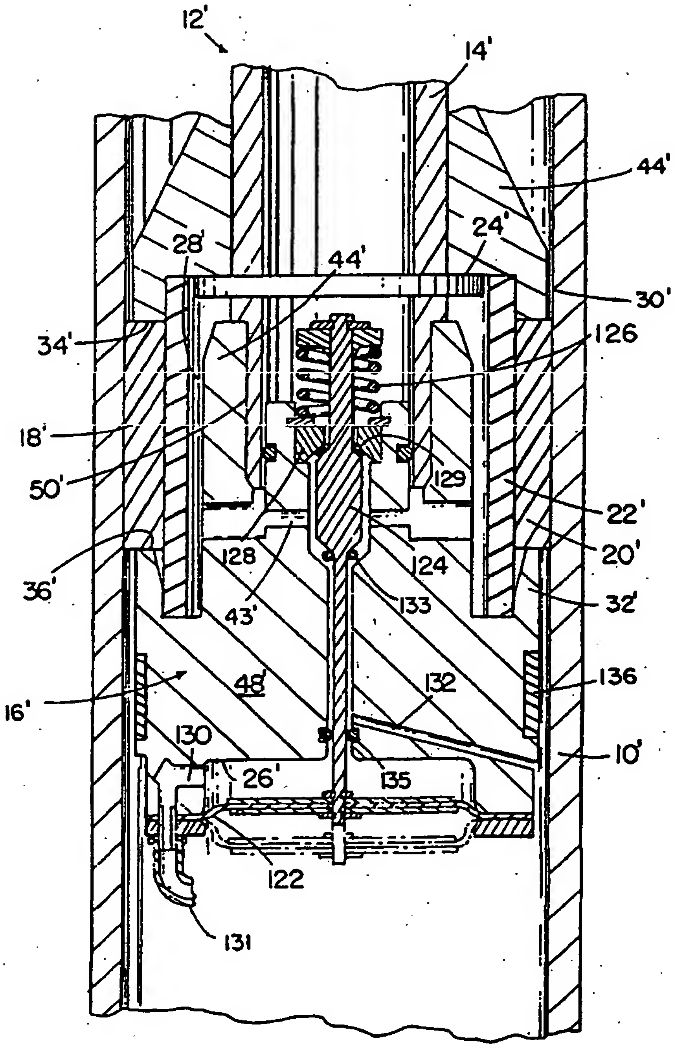


FIG.7


12'
14'
44'
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44'
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126
18'
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129
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124
43'
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32'
136
16'
48'
132
130
10'
26'
135
122
131

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 12 1641

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	GB-A-749695 (DUNLOP RUBBER CO.) * page 1, lines 11 - 80; figures 1-3 *	1, 5	F16F7/08 F16F11/00 F16F9/46 B60G17/06
A	* page 2, lines 72 - 92 * ---	2, 3	
Y	EP-A-0350061 (NIPPONDENSO) * column 3, lines 20 - 23; figures 2, 4-10, 18 *	1, 5	
A	---	7	
A	US-A-2574280 (J. OBERT) * column 1, lines 9 - 55; figures 1, 5, 6 * ---	1-3, 5	
A	US-A-2928507 (SABRE RESEARCH CORP.) * figures 1, 3 * ---	1, 2, 4, 5, 7	
A	US-A-4809179 (FORD MOTOR CO.) * column 5, lines 37 - 62; figures 1, 5-9 * ---	1-3, 5	
A	US-A-2869685 (GENERAL MOTORS CORP.) * column 1, line 43 - column 2, line 27; figures 1, 2 * ---	1, 3, 5	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-2715952 (JONAS WOODHEAD & SONS) * column 3, line 44 - column 4, line 13; figure 2 * ---	1, 2, 4, 5	F16F B60G F16D B64F
A	DE-A-1430178 (MASCHINENFABRIK AUGSBURG-NURNBERG) * page 5, line 12 - page 6, line 4; figures 1-3 * ---	1, 2, 5	
A	FR-A-1185834 (J.E. SNOW) * page 4, lines 30 - 56; figures 3-6 * ---	1, 5	
A	EP-A-0301171 (BOGE) * column 4, lines 47 - 50; figure 6 * -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 JUNE 1991	TSITSILONIS L.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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